cta cherenkov telescope array

TECHNOLOGY

The World's Most Advanced Ground-Based Gamma-Ray Observatory

Credit: Gabriel Pérez Díaz, IAC/ Marc-André Besel, CTAO

Some quick facts about CTAO technology:

CTAO will use dozens of telescopes located in both the northern and southern hemispheres to explore the entire sky.

CTAO's three classes of telescope will provide broad energy coverage from billions to trillions times the energy of visible light (20 GeV to 300 TeV).

The telescope structures will stand between about 9 and 45 metres tall and weigh between 17.5 and 100 tonnes. Despite the largest telescopes' weight and size, they will still be able to rapidly slew towards targets within a few tens of seconds thanks to an ultra-light carbon fibre structure.

CTAO will use thousands of highly-reflective mirror facets (90 cm to 2 m diameter) to focus light into the telescopes' cameras.

CTAO's cameras will use both photomultiplier tubes (PMTs) and silicon photomultipliers (SiPMs) to provide more than 200,000 ultra-fast light-sensitive pixels.

The Observatory is expected to generate approximately 35 petabytes (PB) of data in the first five years of operation (1 PB = 1 million GB).

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Building the next generation very-high energy gamma-ray detector

CTAO is the next generation ground-based observatory for gamma-ray astronomy at very-high energies. With dozens of telescopes located in the northern and southern hemispheres, CTAO will detect high-energy radiation with unprecedented accuracy and a sensitivity that is up to 10 times better than current instruments.

CTAO will be building on the technology of current generation ground-based gamma-ray detectors (H.E.S.S., MAGIC and VERITAS) with an expected tenfold increase in the number of known gamma-ray-emitting celestial objects, detecting more than 1,000 new objects.

More than 1,500 members from 25 countries contribute to the definition of the instrument design and the scientific programme of CTAO. The CTAO gGmbH, which is governed by a growing list of shareholders, will prepare the design and implementation of the Observatory.

The project to build CTAO is well advanced: working prototypes exist for all the proposed telescope designs and significant site characterization and design work has been undertaken. The southern hemisphere site is located close to the existing European Southern Observatory site at Paranal, Chile. The northern array is located at the Roque de los Muchachos astronomical observatory on the island of La Palma, Spain. Construction will begin once the final legal entity of CTAO, an ERIC, is established.

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How CTAO works

The gamma rays that CTAO will detect do not make it all the way to the Earth's surface. When they reach the Earth's atmosphere they interact with it, producing cascades of subatomic particles and a blue flash called Cherenkov light. These cascades are so rare that CTAO will be using dozens of telescopes spread over large areas on two sites (13 telescopes in the north and 51 in the south, in the first construction phase) to improve its ability to detect gamma rays.

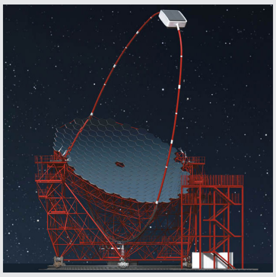
Three classes of telescope types are required to cover the full CTAO energy range (20 GeV to 300 TeV). For its core energy range (150 GeV to 5 TeV), CTAO is planning 23 Medium-Sized Telescopes distributed over both array sites. Four Large-Sized Telescopes and 37 Small-Sized Telescopes are planned to extend the energy range below 150 GeV and above 5 TeV, respectively.

Once the mirrors reflect the light, the CTAO cameras capture and convert it into data. Each telescope has its own variation of camera, but the designs are all driven by the brightness and short duration of the Cherenkov light flash.

A Cherenkov light flash lasts only a few billionths of a second and is extremely faint. The cameras are sensitive to these faint flashes and use extremely fast exposures to capture the light. Photomultiplier tubes (PMTs) or silicon photomultipliers (SiPMs) will convert the light into an electrical signal that is then digitised and transmitted to record the image of the cascade.

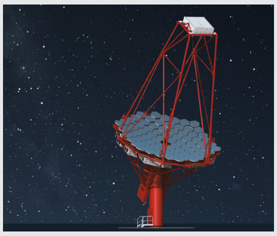
CTAO telescope types

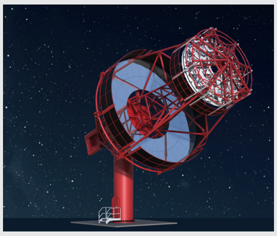
Large-Sized Telescope (LST)



Because gamma rays with low energies produce a small amount of Cherenkov light, telescopes with large mirrors are required to capture the images. The LST mirror will be 23 metres in diameter and parabolic in shape. Its camera will use PMTs and have a field of view of about 4.5 degrees. The entire structure will weigh about 100 tonnes but will be extremely nimble, with the goal to re-position within 20 seconds.

Medium-Sized Telescope (MST)

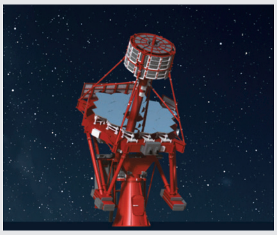




The MSTs will be CTAO's "workhorse." The MST mirror will be 12 metres in diameter and will have two different camera designs that use PMTs. Its large field of view of about 8 degrees will enable the MST to take rapid surveys of the gamma-ray sky.

There are two proposed designs for the MST — the MST (image 1) and a dual-mirrored version, the Schwarzschild-Couder Telescope (SCT). The SCT (image 2) is proposed as an alternative type of medium telescope with greater imaging detail and improved detection of faint sources.

Small-Sized Telescope (SST)



The SSTs will outnumber all the other telescopes and will be spread out over a large area in the southern hemisphere array. This is because very high-energy gamma-ray showers produce a large amount of Cherenkov light but they are rare events. Thus, SSTs are sensitive to the highest energy gamma rays. The SST mirror will be about 4 metres in diameter and will have a large field of view of about 9 degrees.

The SST uses a dual-mirror design that allow excellent imaging across a wide field of view with a short focal length. It makes use of SiPMs in very compact cameras.

Image Credits: Gabriel Pérez Díaz, IAC

The CTA Consortium includes about 1,500 members from more than 150 institutes in 25 countries.